

admirable; a brief sentence is frequently found to contain an accurate and vigorous expression of an elaborate point. On page 3 we are told that "observation is the pitiless critic of theory." We are told that the probability of 61 Cygni forming a connected pair is actually greater than the chance of the sun rising to-morrow morning. We read of inconspicuous minor planets being difficult to detect "in the majestic disguise of a distant sun." We are told how Prof. Adams would not "take any steps to obtain a publicity which he was more anxious to merit than to secure." In referring to the same event, Miss Clerke describes how Lalande narrowly escaped the accidental discovery of Neptune, and adds: "An immortality which he would have been the last to despise hung in the balance; the feather-weight of his carelessness, however, kicked the beam." In speaking of the moon and the possible variations of lunar objects, Miss Clerke says: "A change always seems to the inquisitive intellect of man like a breach in the defences of Nature's secrets, through which it may hope to make its way to the citadel." There are charming bits of biography through the book: as of Olbers, who became a mathematician because he was an astronomer; of Encke, who became an astronomer because he was a mathematician; or of Schwabe, who, seeking his father's asses, found a kingdom.

There are, however, some few omissions, for which we hope in a future edition room will be made. We should have an account of Brünnow's work on stellar parallax. We think also that a history of modern researches on double-stars should include a notice of Dembowski's most elaborate observations; while the labours of Doberck deserve notice, as we owe to this indefatigable astronomer the greater part of our knowledge of the binary-star orbits. Miss Clerke has, however, fully appreciated the splendid work of S. W. Burnham, who has in ten years discovered 1000 double-stars. Those who are aware of the magnificent labours of Prof. Rowland, of Baltimore, on the solar spectrum will be disappointed in not finding some reference in a work of this kind. It must, however, be admitted that a complete account of Prof. Rowland's work has not yet been published.

Miss Clerke's most admirable work fills a widely-felt want. The progress of spectroscopy has been recently so rapid that it was often difficult to find out what was known and what was unknown. It is here that Miss Clerke renders an assistance that every astronomer must appreciate. He can in this volume obtain a vivid and accurate summary of what has been done, or, if he prefers to read the original memoirs, he will be directed where to find them. The work has been most skilfully and faithfully executed, and we heartily recommend it to every one who is interested in the noblest of the sciences.

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#### CRANIOGRAPHY

*Eine exacte Methode der Craniographie.* Von Dr. C. Rieger. (Jena: Verlag von G. Fischer, 1885.)

THIS work contains the description of a method of craniography employed by the author for upwards of five years for obtaining exact geometrical drawings

from the skull or from the head of the living person. The first question dealt with by the author is the plane of orientation of the skull to be adopted. He discards all those which have for their aim the placing of the skull or head in the position natural to man, namely, with the axis of vision as nearly as possible horizontal, and prefers a plane determined by anatomical considerations alone. After studying different anatomical points on the skull for this purpose, he came to the conclusion that the most suitable is a plane running along the base of the cerebrum, extending in front from the angle which the horizontal and vertical portions of the frontal bone make internally with one another to the upper border of the sulcus transversus of the occipital bone, the attachment line of the tentorium cerebelli. This plane placed horizontally is the orientation of the skull adopted by the author. He then proceeds to consider the question of how far the proposed horizontal corresponds to the base of the cerebrum; and secondly, whether it can be determined on the periphery of the unopened skull or the head of the living. Sections of the skull show that the plane corresponds fairly in front with the base of the cerebrum, but posteriorly there is an elevation of the anterior part of the cerebellum and ganglia, so that it does not follow exactly the line of the cerebellum, though roughly it may be said to do so. The determination of the points on the exterior which correspond respectively to the anterior and posterior ends of the plane or long axis of the skull is of greater importance. The anterior point is defined as that point where a line joining the upper borders of the orbits crosses the median line of the skull. The posterior point is more difficult to define, as here several anatomical questions are involved, such as the relation of the protuberantia externa to the interna, and whether the latter corresponds to a fixed point externally. From his investigations the author found that the position of the attachment of the tentorium on which the posterior end of the cerebrum rests cannot be exactly determined in the unopened head or skull, but the variations in position of the external and internal protuberances in comparison to the whole cranial space are so small that the error is infinitesimal. Both in the skull and in the living the termination externally and posteriorly of the plane may be taken as that point where the linea semicircularis superior intersects the protuberantia occipitalis externa in the middle line, or in the living immediately above the line of attachment of the muscles. Having determined these points, he proceeds to show that the outlines of the dimensions of the skull in relation to this plane can be taken only with the assistance of ordinates standing at right angles to one another. He has satisfied himself that it is necessary to have complete outlines of the whole of the curves, and not only the greatest dimensions, so that a model of the skull from which they are taken can be at once apparent. Only a few of the most important curves require to be taken in every case: these are a curve of the ground or horizontal plane, of the median plane, and a third transversely over the cranium in the plane of the external auditory meatus.

The method of obtaining the curves is as follows:—Two threads are tied in the centre so as to form a cross; each end is weighted with lead. The knot is placed in

the middle line on the crown of the head, so that it lies as nearly as possible on the shortest line between the nasion and the protuberantia occipitalis. It is of no consequence whether the knot of the thread lies a little forward or backward. Two arms of the thread are placed anteriorly and posteriorly, one over the nasion, the other over the occiput. The other two are placed transversely across the skull, so that they correspond to the anterior border of each auditory meatus.

The next thing is to fix the points at which the cross-threads cut the line of the ground-plane. For this purpose an elastic band is placed around the skull so that it lies on the anatomical points indicating the anterior and posterior ends of the long axis, and in a straight curve round the skull between these points. When the skull is placed with this line horizontal, we obtain the ground or horizontal plane from which the other curves are to be taken. For the purpose of recording the curves millimetre paper is used, and the principal axes of the skull marked off on it. The long or median axis is measured with calipers. The total length is divided by two, and each half is measured off in a straight line on the millimetre paper from a centre. By a similar process the transverse axis of the skull is obtained at the points where the transverse threads cut the horizontal plane. A rectangular figure is then drawn through each of these points, indicating the length and breadth of the cranium. This forms a boundary-line for the tracing. In order to determine at what point the transverse axis intersects the longitudinal axis in the skull, it is necessary to find out how far behind the mid-point of the long axis the transverse axis is situated. This is done by measuring the distance from the anterior point on the skull to the point where the transverse and horizontal planes intersect at the anterior border of each auditory meatus (which we shall call the "ear-point"), and then marking it off on the millimetre paper, taking as a starting-point the anterior end of the long axis. The true zero or middle point of the skull will be that at which the transverse axis intersects the long axis. This middle point may bear different relations to the middle point of the long axis in that it may coincide with it or be behind it. Whatever may be its relations to the long axis, the transverse axis must be placed on the paper, so that it crosses the centre of the rectangular figure. If the middle point is behind the centre of the long axis, the anterior end of that line will project a corresponding distance beyond the anterior boundary of the figure, while its posterior end will fall at a corresponding distance within it. This will show the projection of the skull forwards and backwards in relation to the anterior borders of the auditory meatus. Should the base of the skull or the ground plane not be symmetrical, the axis of length and that of breadth will not be at right angles to each other, but more or less oblique. Having fixed the position of the axes with respect to the rectangular figure, the horizontal curve is drawn on the paper in four segments in the following way:—A flexible, but absolutely inelastic piece of lead wire is laid on the skull, with its one end corresponding to the right ear-point; it is moulded to the skull, along the horizontal line, to the anterior point in front, then from the left ear-point to the

anterior point, and finally from each ear-point to the posterior point. The segments are then carefully placed on the paper with the points all coinciding to those on the marked quadrilateral, and, with a pencil, a tracing on the paper is made along the inner side of the lead wire. In this way the outlines of several skulls can be superimposed; the transverse and longitudinal axes of all the skulls must, however, be made to coincide.

The median longitudinal curve is taken from the end points of the long axis in two pieces, as it is not possible to take it all at once, and the knot on the cross-threads is utilised for determining a point on the curve from which each segment can be taken. Its position is defined on the paper in the following manner:—With a pair of compasses the distance from the anterior end point to the knot is measured on the skull and then laid off on the paper backwards, starting at the anterior end of the long axis line. The distance from each side point to the knot is measured and laid off on the paper so that the two lines converge and meet in front. The distance of the point of union to the zero will represent the sagittal height of the skull. From the anterior end of the long axis a segment having a radius equal to the distance from the side point to the knot is marked off with the compasses on the paper, and another segment is likewise marked off from the zero point with a radius equal to the distance between the zero point and that at which the two side lines meet. Where the two segments intersect, we have a fixed point which will represent the position of the knot. The accuracy of the point so determined may be further verified by a similar process from the posterior end of the axis line. The lead wire is then laid along the curve, first the one half and then the other, and on being placed on paper is traced with a pencil.

Curves of the transverse diameters of the calvaria are taken in a similar manner.

The method is one which requires a considerable amount of care and time. It has the advantage of not requiring any complicated apparatus, but whether its results are equally reliable and compensate for the time required in the manipulation is possibly an open question. For laboratory work we are inclined to think that the stereograph of Broca will prove much more useful, and repay its cost in the rapidity and accuracy with which all the tracings described in Dr. Rieger's monograph can be made. Moreover, with the stereograph, drawings of the face can be made which are not practicable with the graphic method of Rieger.

The plane of orientation proposed by Rieger cannot be considered quite satisfactory, owing to the difficulty of determining accurately its posterior end. A plane of orientation of a purely anatomical character, which we have frequently used, is that with the basio-nasial line horizontal, it being the axis on which both the brain-case proper and the facial portion of the skull are developed. These anatomical planes have the disadvantage of placing the skull in an unnatural position, but are of the greatest use in comparing outlines of the side view of different skulls. For general purposes, however, we have found the alveolo-condylar plane of orientation to be the most useful.

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